

Comparison of Emergency and Elective Carotid Artery Stenting Treatments: A Single-Center Experience

Eyüp Kaya¹, Mehmet Yücel¹, Mehmet Tahtabaşı², Eyüp Camurcuoglu³, Lokman Tacar¹, Ahmet Serdar Özdemir¹, Gülüstan Şeyhanlı⁴, Veysel Kaya⁵

¹Harran University, Harran Faculty of Medicine, Department of Radiology, Şanlıurfa, Türkiye

²University of Health Science, Mehmet Akif İnan Education and Research Hospital, Department of Radiology, Şanlıurfa, Türkiye

³University of Health Science, Bakırköy Dr. Sadi Konuk Education and Research Hospital, Department of Radiology, İstanbul, Türkiye

⁴University of Health Science, Mehmet Akif İnan Education and Research Hospital, Department of Neurology, Şanlıurfa, Türkiye

⁵Harran University, Harran Faculty of Medicine, Department of Radiology, Şanlıurfa, Türkiye

Abstract

Introduction: This study aimed to compare the clinical and radiological outcomes of emergency and elective carotid artery stenting (CAS) in symptomatic carotid artery stenosis.

Materials and Methods: A retrospective analysis was conducted on 115 patients who underwent CAS for internal carotid artery (ICA) stenosis in our center between January 2020 and May 2023. Patients were categorized as emergency or elective CAS. Data on demographics, comorbidities, antiplatelet use, symptomatic status, acute ischemic infarction history, stenosis degree, plaque characteristics, procedural details (predilatation, embolic protection, complications), intensive care need (>48 hours), hospital stay, and mortality rate were recorded.

Results: Of 115 patients, 68 (59.1%) were male, with a mean age of 69.87 ± 9.17 years. Hypertension (73.9%) was the most common comorbidity. Elective CAS was performed in 96 patients (83.5%) and emergency CAS in 19 (16.5%). Emergency CAS patients had higher rates of ulcerated plaques (47.4% vs. 13.5%), cerebral infarction (84.2% vs. 3.1%), dissection (26.3% vs. 0%), and plaque thrombus (26.3% vs. 1%). Hospital stay was longer in the emergency CAS group (4.74 ± 2.07 vs. 3.63 ± 2.05 days). Myocardial infarction (0% vs. 1%), extracranial complications (5.3% vs. 1%), and mortality (10.5% vs. 3.1%) did not differ significantly. In patients with severe stenosis ($\geq 90\%$), the rate of tandem lesions was higher, periprocedural mortality and prolonged intensive care duration and the rate of predilatation application were significantly higher compared to the other groups.

Conclusion: Emergency CAS is feasible and effective in selected high-risk patients with symptomatic carotid stenosis. However, given the higher risk profile, careful patient selection and perioperative management are crucial.

Key words: Carotid artery diseases; carotid artery stenting; emergency treatment; elective treatment; stroke; postoperative complications.

Introduction

Cerebrovascular events (CVEs) are neurological diseases that impose a significant burden of morbidity and mortality on a global scale. The increase in human lifespan and the aging population contribute to the rising incidence of CVEs (1). Carotid artery stenosis is an important etiology of cerebrovascular diseases and frequently leads to ischemic stroke. Atherosclerosis is the primary pathological process underlying carotid artery stenting (CAS) and is closely associated with comorbid conditions and risk factors such as coronary artery disease (CAD), diabetes mellitus (DM), hypertension (HT), hyperlipidemia (HL), and smoking. The coexistence of these comorbidities can synergistically elevate the risk of carotid artery stenosis and subsequent stroke (1). In clinical practice, the management of carotid

artery stenosis involves lifestyle modifications, medical therapy, and revascularization procedures (2). For patients who do not respond to medical treatment or are at high risk, revascularization methods such as carotid endarterectomy (CEA) and carotid artery stenting (CAS) are considered. While CEA has long been regarded as the gold standard for CAS treatment, CAS is recognized as an alternative to CEA, particularly in patients at high surgical risk (3). Urgent CAS is a treatment option employed in cases involving acute cerebrovascular events like acute ischemic stroke or transient ischemic attack (TIA) (4). The objective of this approach is to rapidly restore blood flow in the acutely occluded carotid artery, thereby ensuring brain perfusion and minimizing neurological damage (5).

*Corresponding Author: Mehmet Tahtabaşı University of Health Science, Mehmet Akif İnan Education and Research Hospital, Department of Radiology, Şanlıurfa, Türkiye E-mail: mehmet.tahtabasi@sbu.edu.tr Orcid: Mehmet Tahtabaşı [0000-0001-9668-8062](https://orcid.org/0000-0001-9668-8062), Eyüp Kaya [0000-0003-4927-5294](https://orcid.org/0000-0003-4927-5294), Mehmet Yücel, [0009-0009-1758-2258](https://orcid.org/0009-0009-1758-2258), Eyüp Camurcuoglu [0000-0002-2382-2555](https://orcid.org/0000-0002-2382-2555), Lokman Tacar [0009-0000-6331-8073](https://orcid.org/0009-0000-6331-8073), Ahmet Serdar Özdemir [0009-0006-2922-5678](https://orcid.org/0009-0006-2922-5678), Gülüstan Şeyhanlı [0000-0002-9092-6493](https://orcid.org/0000-0002-9092-6493), Veysel Kaya [0000-0002-7131-2277](https://orcid.org/0000-0002-7131-2277)

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Table 1: Demographic features of patients who underwent emergency and elective carotid artery stenting

Variables	Total (n=115)	Emergency CAS (n=19)	Elective CAS (n=96)	P value
Age (mean $\pm$ SD), years *	69.87 $\pm$ 9.17	71.26 $\pm$ 8.89	69.59 $\pm$ 9.23	0.529
Gender (male), n (%)	68 (59.1)	11 (57.9)	57 (59.3)	0.423
Symptomatic, n (%)	96 (83.5)	16 (84.2)	80 (83.3)	0.715
Comorbidities, n (%)				
Hypertension	85 (73.9)	14 (73.7)	71 (74.0)	0.723
Diabetes Mellitus	45 (39.1)	8 (42.1)	37 (38.5)	0.325
Coronary artery disease	44 (38.3)	7 (36.8)	37 (38.5)	0.752

CAS: carotid artery stenting, **SD:** standart deviation. **(*)** Age was compared using the independent samples t-test. **Note:** Categorical variables were compared using the Chi-square

In patients with acute ischemic stroke or progressive neurological deficits, urgent carotid revascularization represents a complex trade-off between the potential for rapid restoration of cerebral perfusion and the increased risk of procedural complications, notably reperfusion injury and intracranial hemorrhage (6). However, despite conflicting results in the literature concerning the efficacy and safety of urgent CAS, further data is needed regarding the potential benefits and risks of this approach. This study aims to compare the clinical and radiological outcomes of urgent and elective CAS procedures in patients with symptomatic carotid artery stenosis. By presenting data derived from our single-center experience, we intend to contribute to the ongoing discussions in the literature regarding the applicability and effectiveness of urgent CAS.

Materials and Methods

For this study, ethical approval was obtained from the Harran University Ethics Committee (Date: 04.07.2022, No: HRU/22.13.16).

2.1. Patient Population and Data Collection:

132 patients who underwent CAS due to a diagnosis of extracranial internal carotid artery stenosis between January 2020 and May 2023 at our hospital were retrospectively evaluated. 17 patients with incomplete patient information and those for whom long-term follow-up results could not be obtained were excluded from the study. Consequently, 115 patients who underwent CAS were included in this study. Patients were divided into two groups: those who underwent urgent and elective CAS. Local ethics committee approval was obtained for the study. Due to the retrospective nature of the study and the fact that it did not affect patient clinical care, patient consent was waived. Patient demographic characteristics (age, gender), comorbid diseases (hypertension, diabetes mellitus, coronary artery

disease, smoking, etc.), antiplatelet use at the time of diagnosis, symptomatic/asymptomatic status, the urgency/elective nature of the CAS procedure, a history of acute ischemic infarction within the last 5 days before the procedure, the side of the stenotic segment (right/left), stenosis rates of the stenotic segment (CT angiography, magnetic resonance angiography (MRA), carotid Doppler ultrasound (CDUS), digital subtraction angiography (DSA)), plaque characteristics, contralateral/ipsilateral internal carotid artery (ICA) stenosis rates, technical characteristics during the procedure (application of predilatation/postdilatation, use of distal emboli protection device, development of asystole/bradycardia, procedure-related complications (stroke, death, hyperperfusion syndrome, etc.), need for intensive care (lasting longer than 48 hours), length of hospital stay, and residual stenosis rate were obtained from the hospital's electronic medical records. The final diagnosis of the degree of stenosis was primarily based on DSA findings, as it is considered the gold standard. However, CTA and CDUS were also used as supportive imaging modalities, particularly in the pre-procedural evaluation and in cases where DSA was not available at the time of initial assessment. For statistical analysis, the stenosis rate values obtained from CTA and CDUS were used, since these methods were available for all patients and allowed for standardized comparison across the cohort.

2.2. Definitions: The degree of stenosis was determined according to the criteria of the North American Symptomatic Carotid Endarterectomy Trial (NASCET). According to these criteria, endovascular treatment was applied in the presence of a symptomatic carotid artery stenosis $\geq 70\%$ or an asymptomatic stenosis of at least 80% (7–10). A symptomatic patient was characterized as experiencing a transient ischemic attack, severe dizziness, amaurosis fugax, or a previous

cerebrovascular event within the last six months before the procedure. Emergency stenting was defined as the treatment performed within the first two weeks following an acute stroke. Additionally, emergency CAS included patients with carotid artery stenosis who presented with a significant increase in TIA symptoms, clinical deterioration, decreased Glasgow Coma Scale score, worsening consciousness, or progressive loss of muscle strength. Elective stenting was defined as the treatment performed in patients with symptomatic carotid artery stenosis who did not experience an acute stroke within the preceding month.

2.3. Procedure Technique: CAS procedures were performed similarly in both groups, and the standard CAS procedure was performed in the angiography unit by an experienced interventional radiology team, nurses, and technicians. Before the procedure, all patients were given detailed information about the treatment protocol and possible complications, and written consent was obtained. Patients were monitored without sedation during the procedure to evaluate their neurological status. Vascular access was usually achieved through the right femoral artery, and brachial or radial artery access was used in cases with anatomical difficulties such as bovine type aortic arch variation. At the beginning of the procedure, intravenous heparin was administered to achieve an appropriate activated clotting time (ACT). Diagnostic angiography was performed to evaluate parameters such as stenosis side, stenosis degree, stenosis size, stenosis localization, plaque structure, presence of ulceration, and the presence of stenosis in the distal intracranial ICA. The CAS procedure was performed using a distal emboli protection device (usually filter type). Stent selection was made according to the characteristics of the lesion and vessel anatomy. Predilatation was performed in high-grade stenoses or calcified lesions, and postdilatation was performed in cases where residual stenosis persisted or optimal vessel patency could not be achieved after stent deployment. Intravenous atropine was administered to patients who developed bradycardia or asystole during the procedure. At the end of the procedure, control angiography was performed, and the result was evaluated.

2.4. Statistical Analysis: Statistical analysis of the data was performed using the IBM SPSS 21.0 software package. Categorical variables were presented as numbers and percentages, while continuous variables were presented as mean $\pm$ standard deviation and median values. The chi-

square or Fisher's exact test was used to compare categorical Variables. For comparisons across the three stenosis severity groups, we used the Chi-square test or Fisher's exact for categorical variables. When statistical significance was detected, we performed Bonferroni-adjusted post-hoc pairwise comparisons. Normality was assessed using the Shapiro–Wilk test, and homogeneity of variances was evaluated via Levene's test. Depending on these assumptions, appropriate parametric (t-test, ANOVA) or non-parametric (Mann–Whitney U, Kruskal–Wallis) tests were used. A p-value of <0.05 was considered statistically significant.

Results

3.1. Patient Demographics and Clinical Characteristics: Of the 115 patients included in the study, 47 (40.9%) were female and 68 (59.1%) were male, with a mean age of 69.87 ± 9.17 years (mean age in females 70.47 ± 8.56 , mean age in males 69.46 ± 9.61). 83.5% of the patients were symptomatic, and 16.5% were asymptomatic. The most common comorbid disease was hypertension (73.9%), followed by diabetes mellitus (39.1%) and coronary artery disease (38.3%) (Table 1).

3.2. Procedure Characteristics and Complications: 96 patients (83.5%) underwent elective CAS, and 19 (16.5%) underwent emergency CAS. In the emergency CAS group, compared to the elective CAS group, the presence of ulcerative plaque (emergency: 47.4%, elective: 13.5%, $p<0.001$) (Figure 1),

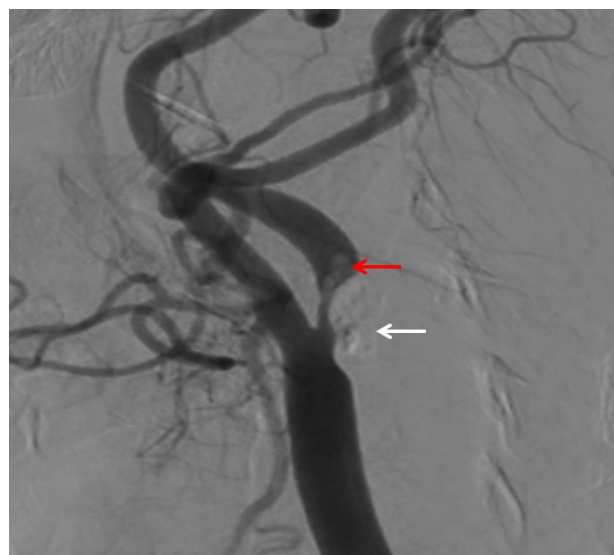


Figure 1: Imaging of a 64-year-old female patient who presented to the emergency department with transient ischemic attacks (TIA). A mixed-type plaque (white arrow) extending from the common carotid artery (CCA) to the proximal internal carotid artery (ICA), along with thrombus material (red arrow), is visualized.



Figure 2: Diffusion-weighted imaging (DWI) and digital subtraction angiography (DSA) images of an 85-year-old female patient who presented to the emergency department with acute stroke symptoms (hemiparesis and vertigo). DWI (a) shows multiple foci in the right frontal lobe consistent with acute ischemia. DSA images demonstrate critical pre-procedural stenosis (b) of the internal carotid artery and successful recanalization following stenting.

Table 2: Comparison of angiographic and clinical features of patients undergoing emergency and elective carotid artery stenting

Variables, n (%)	Emergency CAS (n=19)	Elective CAS (n=96)	p-value
Angiographic features			
Ulsered plaque presence	9 (47.4)	13 (13.5)	0.001
Pre-procedure acute infarction	16 (84.2)	3 (3.1)	0.001
CAS on dissection background	5 (26.3)	0 (0)	0.001
Thrombus presence in plaque	5 (26.3)	1 (1)	0.001
Clinical features			
Length of hospital stay (mean $\pm$ SD), days*	4.74 $\pm$ 2.07	3.63 $\pm$ 2.05	0.033
Periprocedural stroke	2 (10.5)	2 (2.1)	0.519
Periprocedural myocardial infarction	0 (0)	1 (1)	0.946
Periprocedural death	2 (10.5)	3 (3.1)	0.190
Intracranial haemorrhage within 24 hours after the procedure	1 (5.3)	1 (1.1)	0.304

Note: Categorical variables were compared using the Chi-square or Fisher's exact test, as appropriate. (*) The independent samples t-test was used. CAS: carotid artery stenting, SD: standart deviation

a history of acute infarction before the procedure (emergency: 84.2%, elective: 3.1%, $p < 0.001$) (Figure 2), CAS performed on the basis of carotid artery dissection (emergency: 26.3%, elective: 0%, $p < 0.001$), and the presence of thrombus at the plaque level (emergency: 26.3%, elective: 1%, $p < 0.001$) were significantly more frequent (Table 2). Figure 3 demonstrates the imaging findings of an elective patient with a stable carotid plaque who experienced no post-procedural complications. In the follow-up after the procedure, the mean length of hospital stay in the urgent CAS group was significantly longer than in the elective CAS group (emergency: 4.74 $\pm$ 2.07 days, elective: 3.63 $\pm$ 2.05 days, $p = 0.033$). However, no statistically significant difference was found between the two groups in terms of periprocedural stroke (emergency: 10.5%, elective: 2.1%, $p = 0.519$), myocardial infarction (emergency: 0%, elective: 1%, $p = 0.946$), extracranial complications (emergency: 5.3%, elective: 1.0%,

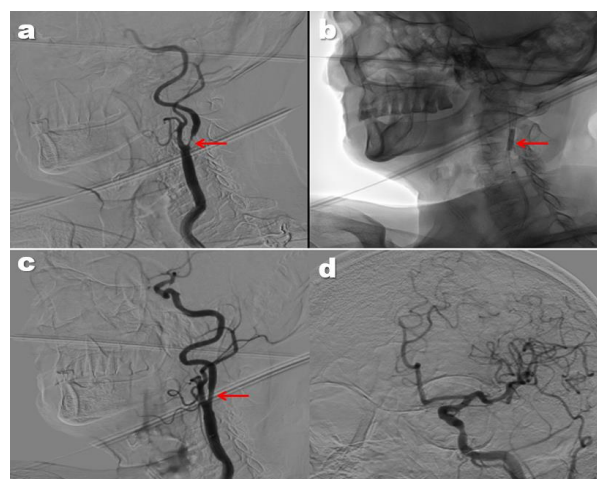


Figure 3: Digital subtraction angiography (DSA) images of a 72-year-old female patient who underwent elective carotid artery stenting for severe stenosis. (a) Lateral view showing >90% stenosis in the left internal carotid artery (ICA). (b) Postdilatation performed due to residual stenosis following stent deployment. (c) Final appearance of the stent demonstrating adequate luminal patency after postdilatation. (d) Intracranial control angiographic image obtained at the end of the procedure.

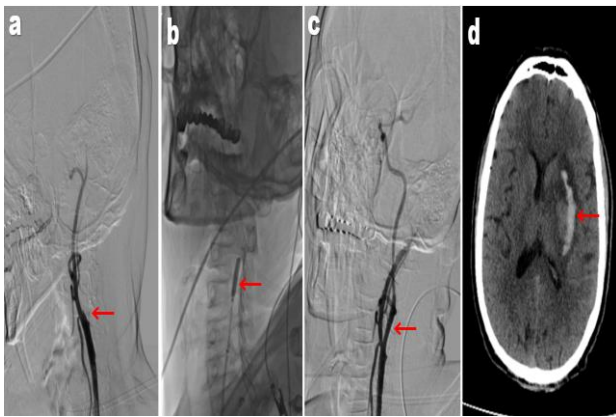


Figure 4: Imaging findings of a 50-year-old male patient who presented to the emergency department with right hemiplegia and impaired consciousness. Digital subtraction angiography (DSA) demonstrates (a) total occlusion of the left internal carotid artery (ICA) (arrow), (b) balloon angioplasty applied to the stenotic segment of the ICA (arrow), and (c) successful recanalization following carotid stenting. A non-contrast brain CT (d) performed at the 24th hour post-procedure shows hemorrhage in the basal ganglia (arrow).

$p=0.835$), and mortality rates (emergency: 10.5%, elective: 3.1%, $p=0.190$). Intracranial haemorrhage within 24 hours after the procedure was detected in two patients (1.7 %). It occurred in 1/19 patients in the emergency CAS group (5.3 %) and in 1/96 patients in the elective CAS group (1.0 %) (OR = 5.28; 95 % CI 0.32–88.30; $p = 0.304$) (Figure 4) (Table 2).

3.3. Degree of Stenosis and Procedure Results: When the degree of stenosis before the procedure was evaluated, the rate of patients with 50-69% stenosis was 11.3% ($n=13$), the rate of patients with 70-89% stenosis was 70.4% ($n=81$), and the rate of patients with 90% and greater stenosis was 18.2% ($n=21$) (according to NASCET criteria with DSA). In patients with 90% and greater stenosis before the procedure, 50% and greater stenosis in the ipsilateral distal intracranial ICA was more frequent than in patients with 50-69% and 70-89% stenosis ($p=0.010$). In addition, periprocedural death ($p=0.037$) and the need for intensive care stay longer than 48 hours ($p=0.017$) were more frequent in patients with 90% and greater stenosis. Predilatation was more frequently applied in patients with 90% and greater stenosis ($p=0.002$) (Tables 3).

3.4. Plaque Characteristics and Coexisting Intracranial Pathologies:

The distribution of patients based on plaque morphology and extension is presented in Table 4. The most common plaque type was mixed, observed in 61 patients (53.2%). Ulceration was

Table 3: Comparison of prognostic factors and angiographic features according to the degree of preprocedural stenosis.

Variables, n (%)	Stenosis degree			P value
	50-69% (n=13)	70-89% (n=81)	≥ 90% (n=21)	
Ipsilateral tandem lesion (intracranial ICA > 50% stenosis)	1 (7.7)	12 (14.8)	10 (47.6)	0.010
Periprocedural death	0 (0.0)	1 (1.2)	3 (14.3)	0.037
ICU stay > 48 hours	0 (0.0)	2 (2.5)	4 (19.0)	0.017
Predilatation performed	0 (0.0)	3 (3.7)	13 (61.9)	0.002

Note: Comparison of groups was made with chi-square test and Fisher's exact. **ICA:** Internal Carotid Artery, **ICU:** Intensive Care Unit

Table 4: Patient distribution according to plaque characteristics on angiography

Variables, n (%)	Total = 115
Plaque type	
Soft	17 (14.7)
Calcified	37 (32.1)
Mixed	61 (53.2)
Ulcerated plaque	
Yes	22 (19.2)
No	93 (80.8)
Contralateral extracranial ICA > 50% stenosis	
Yes	44 (38.3)
No	71 (61.7)
Ipsilateral ICA distal intracranial segment > 50% stenosis	
Yes	23 (20.0)
No	92 (80.0)
Contralateral ICA distal intracranial segment > 50% stenosis	
Yes	17 (14.8)
No	98 (85.2)
Lesion origin/course	
ICA	27 (23.5)
CCA-ICA	24 (20.9)
CCA-ICA-ECA	64 (55.6)

ICA: internal carotid artery, **ECA:** external carotid artery, **CCA:** common carotid artery

present in 22 plaques (19.2%). Additionally, tandem lesions (ipsilateral intracranial ICA stenosis) were identified in 23 patients (20.0%).

Discussion

This single-center retrospective study holds clinical significance as it is among the limited number of studies comparing urgent and elective CAS procedures in patients with symptomatic CAS. A key finding of our study is that a higher-risk patient population was treated in the urgent CAS group. The more frequent occurrence of adverse prognostic factors such as ulcerative plaque, a history of acute infarction, carotid artery dissection, and the presence of thrombus in the plaque within the urgent CAS group suggests that this patient group presents with greater complexity and is more challenging to manage. The literature presents varying perspectives on the outcomes of urgent CAS. Some research indicates that urgent CAS is associated with higher rates of periprocedural complications, while other studies have demonstrated results comparable to those of elective CAS (11,12). For instance, Orozco et al., in their retrospective study, reported higher ipsilateral carotid occlusion rates and longer hospital stays in patients undergoing urgent CAS (11). However, they found no significant differences between the two groups with respect to the presence of ulcerative plaque, the development of dissection, or periprocedural events. Consistent with the findings of Orozco et al., our study also observed longer hospital stays in the urgent CAS group. This finding may be attributed to the more severe clinical conditions, higher comorbidity rates, and the need for more intensive monitoring and treatment in patients undergoing urgent CAS. Nevertheless, one of the most noteworthy findings of our study is the absence of a significant difference between the urgent and elective CAS groups in terms of periprocedural stroke, myocardial infarction, and mortality rates. This observation can be attributed to factors such as the stringent patient selection criteria employed at our center, procedures performed by experienced operators, the routine use of emboli protection devices, and aggressive perioperative management. Notably, the use of distal emboli protection devices plays a crucial role in reducing the risk of distal embolization during CAS, thereby lowering periprocedural stroke rates (13,14). Underscores an important contribution of our study, suggesting that urgent CAS can be a safe and effective option, even in high-risk patients, when approached with caution. Our study, unlike some in the literature, included patients with stenosis of 90% and greater. This difference in patient selection, along with the presence of ulcerative plaque structure and a high thrombus burden, as well as the poor general

condition of the patients, may explain the differences observed during and after the carotid artery stenting (CAS) procedures (15–18). This factor enhances the originality and clinical relevance of our study in evaluating CAS outcomes in a high-risk patient cohort. Particularly, the decision for urgent revascularization in patients with acute stroke or progressive neurological deficits and high-grade carotid artery stenosis necessitates a careful evaluation of the potential benefits and risks (9,16–18). In this regard, the findings of our study provide valuable insights into the applicability and outcomes of CAS in this challenging patient population. Our study also identified significant correlations between the degree of stenosis before the procedure and the procedural outcomes. Patients with high-grade stenosis (particularly $\geq 90\%$) demonstrated a higher incidence of periprocedural mortality, prolonged intensive care unit (ICU) stays, the necessity for predilatation, and ipsilateral intracranial internal carotid artery (ICA) stenosis. These findings indicate that severe extracranial stenosis is often associated with more complex vascular pathology, a heightened embolic risk, and a more fragile clinical profile. This underscores the importance of carefully assessing the degree of stenosis when planning carotid artery stenting (CAS), as higher-grade stenosis may necessitate more aggressive interventional strategies (e.g., predilatation, longer or multiple stents) and meticulous post-procedural monitoring. Furthermore, such patients may have coexisting intracranial vascular pathologies, necessitating a more comprehensive neurovascular evaluation prior to intervention. In particular, the presence of tandem lesions—defined as concurrent extracranial and intracranial ICA stenoses—deserves special attention. Several studies have demonstrated that tandem lesions are associated with worse clinical outcomes, lower recanalization rates, and higher risk of periprocedural complications compared to isolated stenosis (15–18). In our cohort, a noteworthy proportion of patients with $\geq 90\%$ stenosis also exhibited tandem lesions, which likely contributed to the increased rates of adverse outcomes. Therefore, early identification of tandem pathology through appropriate imaging and careful planning of the intervention (including the potential for staged or combined treatment) is essential to optimize CAS success and minimize risks. Our study has some limitations. The retrospective study design, the relatively small sample size, and the data being derived from a single center limit the generalizability of the findings. Additionally, the

lack of long-term follow-up data precludes an assessment of restenosis and late complications. Therefore, it is necessary to confirm our results with prospective studies involving larger patient populations and multiple centers. Such studies could provide more comprehensive guidance for clinical practice by evaluating the long-term outcomes, patient quality of life, and cost-effectiveness of urgent and elective CAS procedures. Specifically, further research in areas such as the optimization of urgent CAS procedures, the refinement of patient selection criteria, the standardization of perioperative management protocols, and the evaluation of long-term outcomes will enhance our understanding and improve patient care.

Study limitations: This study has several limitations that should be acknowledged. First, it was designed as a single-center, retrospective study, which may limit the generalizability of the findings. The allocation of patients into emergency and elective carotid artery stenting groups was not randomized, which introduces a potential selection bias and may have influenced baseline differences in clinical and anatomical characteristics. Second, the number of patients in the emergency CAS group was relatively small compared to the elective group, which may have reduced the statistical power of some analyses. Additionally, some clinical and radiological data, such as detailed plaque morphology, collateral circulation, and serial neurological assessments (NIHSS, mRS), were not available for all patients. Third, procedural techniques, including the choice of stent type, use of embolic protection devices, and operator experience, were not fully standardized and may have varied between patients. In emergency cases, time constraints could have affected pre-procedural planning and imaging protocols compared with elective procedures. Lastly, the follow-up period was limited, preventing a comprehensive evaluation of long-term outcomes such as restenosis, late stroke, or mortality. Differences in post-procedural antiplatelet therapy duration and patient compliance may also have influenced clinical outcomes. Despite these limitations, this study provides valuable real-world data comparing emergency and elective carotid artery stenting and contributes to the existing literature on clinical decision-making in acute settings.

Conclusion

This single-center retrospective study demonstrates that urgent CAS procedures in selected patient populations with symptomatic

CAS have an acceptable safety and efficacy profile. However, given that urgent CAS is performed in a higher-risk patient group compared to elective CAS, careful patient selection and meticulous perioperative management are of paramount importance. The decision to perform urgent CAS should be made through a multidisciplinary approach, with a thorough evaluation of clinical and radiological risk factors in patient selection. Future prospective, randomized controlled trials will provide more definitive evidence regarding the optimal timing of urgent CAS, patient selection, and long-term outcomes.

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Ethical approval: For this study, ethical approval was obtained from the Harran University Ethics Committee (Date: 04.07.2022, No: HRU/22.13.16).

Conflict of interest: There is no conflict of interest among the authors.

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